MPTA-C5c-2010 R2015

Common Causes of Jaw Coupling Failures

MPTA Primer

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Abstract

This guideline is intended to provide users with a general overview of the most common causes of failure with elastomeric Jaw and Curve jaw couplings and their causes

Foreword

This Foreword is provided for informational purposes only and is not to be construed to be part of any technical specification. It is intended for informational purposes only

Scope

This guideline is intended to provide users with a general overview of the most common failure modes with Elastomeric Jaw and Curve jaw couplings and their causes.

Jaw Coupling Failures

Introduction

Figure 1

Jaw couplings are the most popular type of flexible coupling in the world. They provide an economic solution to many of the coupling requirements for power transmission in a large number of applications. All too often, proper care is not exercised in selecting and installing jaw couplings, or these couplings might be used in applications that are not well suited for their design. Mistakes can be made in sizing couplings, selecting the most suitable elastomers, installing couplings, and ongoing maintenance, all which may lead to premature element, or spider, failure. Additional jaw coupling failures include misalignment, chemical/temperature exposure, over-torque (or overloading), and improper coupling selection for a specific application. The objective of this report is to help identify the characteristics of different failure modes and offer suggestions to assist in the proper selection and installation of jaw couplings.

Inserts, or spiders, used in jaw couplings are designed to be the primary 'wear' component in the coupling. Understanding the difference between normal wear and abnormal wear is critical to proper coupling maintenance.

What is "normal wear"?

A frequently asked question about jaw couplings is: "How long should the spider in jaw couplings last?" There are many factors that make this question difficult to answer. Things that influence the life of an insert or spider include:

- Proper selection
- Misalignment
- Over-torque
- Environment effects (chemical exposure and excessive temperature)
- Environmental contaminants (abrasive dust, sand, sawdust, etc)
- Torsional vibration or improper application

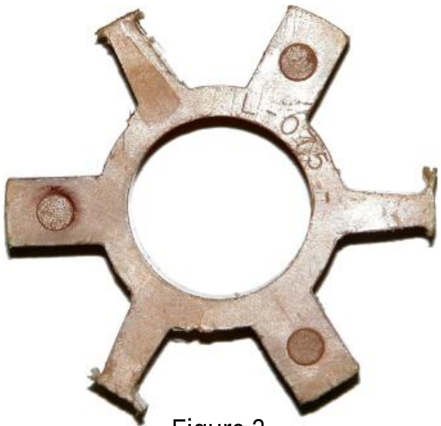

Figure 2

These conditions contribute to both normal and abnormal spider wear.

The elastomer, or spider, acts as a cushion between the metal jaws of the two coupling hubs. The driving hub pushes the driven hub through the spider resulting in an expected compression of the elastomer. Normal wear of a jaw coupling spider is not considered destructive wear but is instead a compressive "set" of the elastomer. Compressive "set" is defined as the decrease in the thickness of the spider leg as seen in figure 2 and is considered normal wear of the spider ages while in service.

This particular spider (figure 2) was used in a non-reversing application. The normal limit of allowable wear is roughly 20-30% of volume loss in the three spider legs that typically transmit torque.

Compression is only applied to the spider legs forward of the driving jaws and the trailing legs behind the driving jaws remain relaxed. Accordingly, when compressive set reaches 70-80% (representative of most manufacturers' standard) of its original spider leg volume, the spider needs to be replaced. If alternating spider legs display compression, the spider can be rotated by one leg advancing the good legs into the driving position. This is an acceptable step to take until a replacement spider can be installed. In reversing applications, all spider legs would show wear and the spider should be replaced immediately.

The following sections will provide assistance you in identifying these various conditions and possible solutions.

Misalignment

After transmitting torque, the primary function of a flexible jaw coupling is to provide the capability to compensate for angular and parallel misalignment. Angular misalignment is handled through the sliding or distorting of the elastomeric material by amounts dependent on the jaw geometry of the elements and hubs. Parallel misalignment is handled via the compressive distortion of the elastomeric material.

This section will address the different insert, or spider elastomer materials, their features related to resolving misalignment, and the common signature failures that can be a direct result of misalignment.

Coupling manufacturers offer jaw coupling inserts, or spiders, in a variety of elastomer materials; materials which influence the capability of the coupling to handle misalignment. The following table (Table 1) covers the misalignment capacity of standard straight jaw style couplings.

Table 1

	Misalignment	
Characteristics	**Angular (Degree)**	**Parallel (Inch)**
NBR - Nitrile Butadiene (Buna N) Rubber	1°	0.015
URETHANE	1°	0.015
HYTREL	½°	0.015
BRONZE	½°	0.01

Curved jaw couplings have slightly different ratings based on the durometer rating of the elastomer material as well as the curved design of the jaws and the corresponding spider legs. Table 2 covers the allowable misalignment for the curved jaw couplings.

Table 2

			Misalignment	
Spider Type	**Color**	**Material**	**Angular (Degree)**	**Parallel (inch)**
80 Shore A	Blue	Polyurethane	.9 - 1.3	.008 - .027
92 Shore A	Yellow/White	Polyurethane	.9 - 1.3	.008 - .027
95/98 Shore A	Red	Polyurethane	.9 - 1.3	.008 - .027
64 Shore D	Green	Polyurethane	.9 - 1.3	.008 - .027

An important factor to consider is that the combination of both angular and parallel misalignment will decrease the coupling's capacity to correct for application misalignment. This combination will likely cause a highly accelerated rate of wear in the spider and/or hubs eventually resulting in failure. A third type of misalignment in jaw couplings is "axial misalignment", or displacement, which is the axial movement or incorrect spacing of one shaft relative to the other. Axial misalignment can cause the coupling to disconnect or cause an in-shear condition that would destroy the spider. If the hubs are too close together, this axial misalignment can actually inhibit any capacity of the coupling to compensate for angular or parallel misalignment.

When a coupling fails due to misalignment, this type of failure is easy to identify provided the spider has not been destroyed. Angular wear marks on the tooth or leg of the spider are typical failure signatures caused by excessive misalignment as indicated in figure 3.

Knowledge of the amount of misalignment a coupling can handle and understanding how to identify failures due to misalignment can lead to better coupling selection and maintenance to increase coupling life. Coupling manufacturers generally provide detailed instructions for the selection and installation of jaw couplings. The installation instructions usually cover proper alignment procedures in detail and these instructions should be referred to prior to installing jaw couplings.

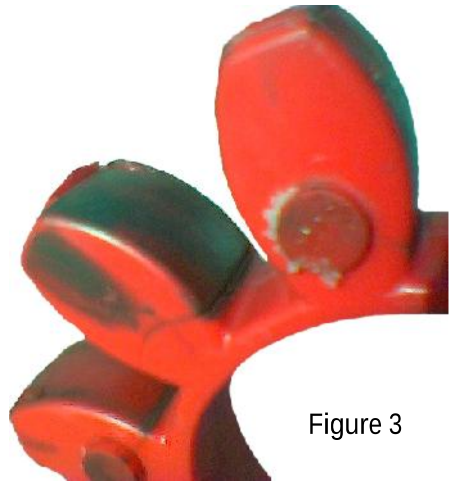

Figure 3

Over-Torque

Couplings are designed to transmit torque from one shaft to another through the coupling hubs and spider. The weakest link in a jaw coupling is the insert, or spider, and the coupling's torque capacity is determined by the rated capacity of the elastomer to transmit torque. When the elastomers' capacity to transmit torque is exceeded, an over-torque, or over load, situation can exist. This happens when the coupling has not been correctly sized for an application and typically results in the failure of the coupling, sometimes catastrophic (see figure 4). A major factor influencing the selection of a coupling is the use of service factors to adjust the application torque for specific applications. When an incorrect service factor is selected or this calculation is not done properly, spider failure and often hub failure will occur. Charts listing appropriate service factors for various applications are provided by most coupling manufactures. See figure 5 for an additional example of a coupling that was subjected to torque overload.

Figure 4

Figure 5

Both straight and curved jaw couplings have nominal torque ratings. The nominal torque rating is determined by the design and material of insert used in the coupling assembly. As stated above, the elastomer is typically the weakest link in a jaw coupling, so the torque rating of the hub does not factor into the nominal torque rating of the complete jaw coupling. The coupling jaws usually have a torque capacity several times that of the spider. An over-torque situation occurs when the adjusted application's nominal or start up torque is greater than the nominal torque rating of the spider illustrated in figure 5.

Straight and curved jaw over-torque failures appear as a severing of the legs from the spiders, causing the jaw on one hub to come into contact with the jaw on the opposing hub. The fact that the coupling will continue to operate, even though the spider has been destroyed, makes this a failsafe coupling. The spider should be replaced without delay, otherwise the jaws will break and the two pieces of machinery will be disconnected. Over torque in the curved jaw design can also take the form of a "squaring" of the open center of the spider as illustrated in figure 6.

To properly size a jaw coupling several factors should be evaluated; the driving horsepower, the speed or RPM of the motor, the type of driven equipment to be connected, shaft sizes, the distance between shaft ends, and run cycle (cyclical or continuous). With the horsepower and RPM, a nominal torque figure can be calculated. Cross referencing the type of driven equipment with charts available from coupling manufacturers will provide a service factor that is used as a multiplier to arrive at the design torque for an application. By using this process, the coupling selection will provide the best possible service life for the application.

Another signature failure for a jaw coupling in an over load condition is what is referred to as "keyway burst" as illustrated in figure 7. Applying excessive torque or excessive interference fit to a coupling can cause the hub to break starting at the top corner of the keyway where the thinnest cross section occurs. The end result is the hub will split in half as seen in the picture.

Understanding what coupling components look like after an overload condition can help you to better understand the importance of a proper selection practice.

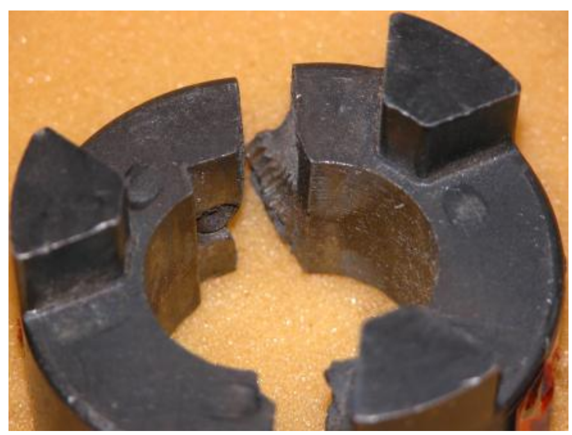

Figure 7

Chemical & Temperature

Careful consideration of the types of chemicals and/or the range of temperatures that a coupling is exposed to, can aid in a better elastomer selection. There are no inserts manufactured today that can withstand the complete gamut of chemicals prevalent in industry, so this section will address some of the factors used in selecting the proper elastomer.

As discussed before, there are several types of elastomeric inserts and each reacts differently under the influence of different chemicals and temperature ranges. Due to these elastomer choices, the straight jaw coupling has considerable flexibility when exposed to different chemicals. Coupling manufacturers provide guides to elastomer materials and information covering chemical resistance. When a spider is exposed to a chemical it is not compatible with, the elastomer material will break down quickly, often causing a rapid failure of the spider. Care should be taken at the time of coupling/spider selection to avoid issues related to chemical exposure. This added care in selection can result in a longer life for the coupling.

Exposure to extreme temperature has always been a factor in selecting an elastomeric insert or spider for a jaw coupling. Many applications require adjustments in application designs to move away from elastomeric couplings to all metal coupling designs to counter issues raised due to temperature. Still, with the different materials offered with the straight jaw spider there is a variety in the temperature ranges where these couplings can operate (see table 4).

Table 4

Characteristics	Temperature Range
NBR - Nitrile Butadiene (Buna N) Rubber	-40 to +212°F
URETHANE	-30 to +160°F
HYTREL	-60F to +250°F
BRONZE	-40° to +450°F

The temperature ratings for curved jaw coupling Urethane elastomers vary slightly from the straight jaw ratings for the various materials. The durometer shore hardness and chemistry of the urethane differs, resulting in the temperature ratings listed in Table 5.

Table 5

Spider Type	Color	Material	Temperature Range
80 Shore A	Blue	Polyurethane	-40 to 212 F
92 Shore A	Yellow	Polyurethane	-40 to 212 F
92 Shore A	White	Polyurethane	-40 to 212 F
95/98 Shore A	Red	Polyurethane	-40 to 212 F
64 Shore D	Green	Polyurethane	-30 to 230 F

One indicator that an elastomer has had prolonged exposure to heat is cracks that will appear on the legs of the spider. The Buna-N material can be especially susceptible to this failure while the urethane will prove more resistant.

When making coupling selections, the user will need to take into consideration both chemical exposure and the temperature of the environment where the coupling will be operating. This will result in better coupling selection and longer life.

Torsional Applications

Jaw couplings are an economic or inexpensive way to address power transmission coupling issues in a wide variety of applications. Frequently, jaw couplings have been used in applications where cost controls the coupling selection over a good understanding of the capability of the jaw coupling design. Many of these applications include the use of jaw couplings with reciprocating equipment, or what is referred to as torsional applications. This section will address some of these applications and the types of elastomer failures related to improper selection of jaw couplings in a torsional situation.

Reciprocating engines such as diesel, gasoline, liquid propane, and natural gas generate torsional, or high frequency, vibrations. Likewise, reciprocating pumps and compressors generate similar high frequency vibrations. These high frequency vibrations are not as easily detected as lateral vibrations that you can feel. If not dampened out of a system, these vibrations can cause damage to both engines and driven equipment. Due to the attractiveness of their low cost, jaw couplings are often selected for the purpose of dampening these torsional and lateral vibrations. Under normal operating conditions the elastomeric material, or spider, through a process known as hysteresis, will attempt to dampen these vibrations by converting the dynamic energy of the vibrations into heat through molecular friction, and then dissipate this as heat. If the coupling is not able to disperse the generated heat, the insert or spider material will build up enough heat to literally melt the spider from the inside out. The characteristic failure due to hysteresis appears as melted material 'oozing' or pouring from the end of the spider legs as seen in figure 8.

Figure 8

Different spider materials will display slightly different abilities to dissipate the heat, but without changing size or moving to torsional style couplings, the end result will usually be the same as seen in the picture. In limited cases, vibrations caused by reciprocating equipment can be dampened to a satisfactory amount though the use of a jaw type coupling. This process of changing elastomeric materials or hardness ratings involves using inserts with different torsional "stiffness" values and is referred to as "tuning" the system. By using "stiffer" or "softer" jaw coupling elastomers the natural frequency of the engine can be shifted away from the normal operating speed of the engine. With jaw couplings this is strictly a "hit or miss" adventure. When designing couplings into applications involving these high frequency vibrations, torsional couplings are often the best substitution.

Hub failure

If worn spiders are not replaced, the legs will eventually wear or shear off leaving no cushioning between the hubs' metallic jaws. As stated previously, the coupling will continue to operate through jaw-to-jaw contact. This metal to metal contact will eventually cause jaw failure as illustrated in figure 9.

Even if the jaws do not break off from the hub, they may have suffered damage from the metal to metal contact. Hubs should be carefully inspected for cracks or chips before spider replacement.

Figure 9

Conclusion

By establishing a regular inspection schedule for elastomeric couplings followed by proper maintenance of the spiders, greater coupling life can be achieved.

The purpose of this report was to provide background on jaw coupling application uses and information regarding common modes of failure. By understanding the benefits and limitations of jaw couplings, the coupling selection process can be greatly improved. The desired end result will be jaw couplings that can be utilized in applications where they can provide the best possible performance.